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L74	L70 and visible with light	3	L74
L73	L70 and electromagnetic with field	0	L73
L72	L70 and support with substrate	0	L72
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L70	L69 and converg$3 with lens	3	L70
L69	L68 and substrate	3	L69
L68	gyricon with optical with lens	3	L68
L67	gyricon with particles with optical with lens	0	L67
L66	L65 and spheroidal	1	L66
L65	L61 and dimensional	1	L65

L64	L61 and 3D	0	L64
L63	L61 and converg$3 with lens	0	L63
L62	L61 and spheroid with balls	0	L62
L61	L59 and rotat$3 with particles	1	L61
L60	L59 and rotat$3 withy particles	441559	L60
L59	L58 and electromagnetic	2	L59
L58	L57 and lens	4	L58
L57	L55 and transparent	16	L57
L56	L55 and transparent with lens$1	0	L56
L55	L54 and anisotropic	16	L55
L54	6055091	20	L54
L53	L52 and "non-conductive"	0	L53
L52	L51 and magnet$6	11	L52
L51	L50 and insulat$4	13	L51
L50	L49 and reflect$5	31	L50
L49	L48 and pixels	31	L49
L48	((359/$3).ccls.) and flexible with electric with paper	32	L48
L47	((359/$3).ccls.) and flexible electric with paper	12144	L47
L46	L45 and "non-display" with period	1	L46
L45	LCD with image with display with period	79	L45
L44	LCD with image with signal and chang$3 with ratio with display with period and non with display with period	2	L44
L43	6344889	1	L43
L42	virtual with shop with area	2	L42
L41	virtual with shop with area and 3D	0	L41
L40	L39 and PWM	59	L40
L39	L38 and light with intensity	1438	L39
L38	L37and adjust$3 with driv$3 with signal	11402	L38
L37	display with LEDs and voltage with measur$6	2028	L37
L36	display with LEDs and voltage with measur$6 with voltage	2028	L36
L35	L34 and measur$3 with voltage	1	L35
L34	L33 and display with LEDs	4	L34
L33	alexander with eisen	75	L33
L32	L31 and display with LEDs	3	L32
L31	ali same zamani	79	L31
L30	L27 and PW	0	L30
L29	L27 and PWM	0	L29
L28	((345/$3).ccls.) and display with LEDs and driv$3 with unit and measure$3 with voltage with LEDs	3	L28
L27	L26 and memory	1	L27

L26	L25 and adjust$3 with drive$3 with signal	1	L26
L25	L24 and threshold with voltage	4	L25
L24	L23 and current with source	7	L24
L23	((345/$3).ccls.) and display with LED and driv$3 with unit and measure$3 with voltage	17	L23
L22	((315/$3).ccls.) and display with LED and driv$3 with unit and measure$3 with voltage	13	L22
L21	((315/$3).ccls.) and display with LED and driv$3 and measure$3 with voltage with LED	3	L21
L20	6476563	2	L20
L19	L18 and solenoid	6	L19
L18	animated with video and driv$3 with transparent	13	L18
L17	animated with video and driv$3 transparent	263763	L17
L16	L15 and driv$3 with transparent	0	L16
L15	5716682	3	L15
L14	L13 and solenoid	0	L14
L13	5724758	11	L13
L12	L11 and solenoid	0	L12
L11	5757545	7	L11
L10	L9 and lenticular	0	L10
L9	animat$2 with video with device	63	L9
L8	L5 and speaker with sound	3	L8
L7	L5 and animal with stuff	0	L7
L6	L5 and lenticular$5	0	L6
L5	greeting with card and solenoid	48	L5
L4	L3 and animat$5	1	L4
L3	L2 and transparent	10	L3
L2	L1 and solenoid	20	L2
L1	lenticular with image	1218	L1

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DATE: Friday, March 07, 2003 Printable Copy Create Case

Set Name side by side	Query	Hit Count	Set Name result set
	DB=USPT; PLUR=YES; OP=OR		
L91	L90 and rotat$3 with particles	2	L91
L90	L89 and lenses	5	L90
L89	L88 and spheroid$5 with ball	6	L89
L88	5815306	19	L88
L87	L85 and trnaparent with film with lens	0	L87
L86	L85 and trnaparent with lens	0	L86
L85	5815306	19	L85
L84	gyricon with rotat$3 with electromagnetic	0	L84
L83	L80 and lenses	2	L83
L82	L80 and transpare$5 with lenses	0	L82
L81	L80 and transparent with lenses	0	L81
L80	display with chromatic with particles	8	L80

L79	L77 and electromagnetic	0	L79
L78	L77 and filler	0	L78
L77	L76 and opaque	3	L77
L76	L75 and "three-dimensional"	3	L76
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L74	L70 and visible with light	3	L74
L73	L70 and electromagnetic with field	0	L73
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L22	((315/$3).ccls.) and display with LED and driv$3 with unit and measure$3 with voltage	13	L22
L21	((315/$3).ccls.) and display with LED and driv$3 and measure$3 with voltage with LED	3	L21
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L19	L18 and solenoid	6	L19
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L17	animated with video and driv$3 transparent	263763	L17
L16	L15 and driv$3 with transparent	0	L16
L15	5716682	3	L15
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L3	L2 and transparent	10	L3
L2	L1 and solenoid	20	L2
L1	lenticular with image	1218	L1

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arrays are precision molded (e.g., by injection molding) of transparent plastic. They can be made in any array geometry, for example a hexagonal geometry (as shown in FIG. 11B) or a rectangular geometry. Preferably, the geometry and inter-lens spacing are the same for both the fly's eye array and the spherical lens array, to ensure that proper registration (that is, mutual alignment) of the two arrays can be achieved. For this reason, the lens array itself is used to pattern the eggcrate structure that contains the spherical lens balls, as will be described below. The width of each microlens of the fly's-eye array (that is, the linear dimension of a chord formed by connecting the two vertices of the lens along the planar portion of the lens) is preferably the same as the diameter of the eggcrate cavity, so as to maximize light transmission efficiency from the lens into the spherical lens array.

Detailed Description Text (70):
A portion of an empty eggcrate substrate 120 is illustrated in a side view in FIG. 12A, and in a three-dimensional cutaway view in FIG. 12B. Substrate 120 has transparent front and rear surfaces 125, 126 and contains a geometrically regular array of uniform cavities 123, which in this embodiment are cylindrical and are arranged in a monolayer in a closely packed hexagonal array geometry (as indicated by hexagon H). The cavity walls can be made opaque to reduce light leakage. Each cavity is filled with a transparent dielectric fluid (not shown), such as an oil, in this embodiment with an index of refraction closely matching that of the transparent material of substrate 120. In a working gyricon display, one ball is placed in each cavity of the eggcrate, as shown in FIG. 12C, where spherical lens balls 121 occupy cavities 123. Each ball 121 acquires an electrical dipole moment when immersed in the dielectric fluid that fills cavities 123.

Detailed Description Text (71):
The diameter of cavities 123 is slightly larger than that of balls 121, but preferably no larger than necessary to ensure proper rotation of balls 121 upon application of an electric field. Similarly, the depth of cavities 123 is only slightly larger than the diameter of balls 121, so as to minimize translation of the balls within the cavities and thus to maintain the balls at the proper focusing distance with respect to the lens elements of the fly's-eye array.

Detailed Description Text (72):
It is desirable to pack balls 121 as closely together in the gyricon display as possible, preferably in a monolayer. The close-packed monolayer arrangement maximizes the efficiency of light transmission by the inventive gyricon display. A hexagonal packing geometry maximizes the density of imaging elements, although a rectangular or rhomboidal geometry can also be used. Making the walls of cavities 123 as thin as is consistent with structural integrity tends to maximize the ball packing density for any given geometry.

Detailed Description Text (77):
When RISTON is exposed to ultraviolet light, it photohardens, so that when subsequently placed in a high-pH aqueous development solution, only the unexposed portions are dissolved. Thus RISTON can be etched to form the cylindrical cavities of the eggcrate substrate. Specifically, the photomask with the array of spots that was formed from the fly's-eye lens array is placed in contact with the RISTON surface of the coated glass plate. The assembly is then exposed to highly collimated ultraviolet light from a photoresist exposure system. This light is unable to penetrate the dots on the photomask, but all other parts of the RISTON surface are exposed and thus photohardened. Thereafter, the photomask is removed and the RISTON-coated glass plate placed in the aqueous development solution. The areas of the RISTON that were underneath the photomask spots during the UV exposure are dissolved away by the developer, leaving holes that are nearly cylindrical. (In practice, the holes are slightly tapered such that the diameter of the hole adjacent to the glass plate is less than that at the air interface.)

Detailed Description Text (78):
A portion of the partially formed eggcrate structure 150' at this stage of fabrication is illustrated in FIG. 14. RISTON layer 151 contain cavities 152, and is topped by a flat surface 153 formed by the unetched RISTON. Layer 151 is situated atop transparent plate 154 which is overcoated with ITO electrode 155 as shown. The thickness of layer 151 is typically 4 mils; the thickness of plate 154 is typically 30 to 40 mils.

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L92: Entry 1 of 5 File: USPT Nov 12, 2002

DOCUMENT-IDENTIFIER: US 6480322 B2
TITLE: Method of improving the respondability of moveable structures in a display

Detailed Description Text (3):
The present invention is a method for improving the rotatability of a plurality of moveable optically anisotropic particles in a visual display such as the moveable particles in a gyricon display. This objective is attained by heating the display, preferably in conjunction with shearing or torquing the moveable structures therein (see, e.g. FIG. 5). The electrically and optically anisotropic particles are agitated by applying a reversing electrical or magnetic field to the balls, causing the particles to rotate back and forth.

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L74: Entry 1 of 3 File: USPT Jun 29, 1999

DOCUMENT-IDENTIFIER: US 5917646 A
TITLE: Rotatable lens transmissive twisting ball display

Brief Summary Text (4):
U.S. patent application Ser. No. 08/773,664 entitled "`Eggcrate` Substrate for a Twisting Ball Display."

Brief Summary Text (12):
An exemplary gyricon display 10 is shown in side view in FIG. 1 (PRIOR ART). Bichromal balls 11 are disposed in an elastomer substrate 12 that is swelled by a dielectric fluid creating cavities 13 in which the balls 11 are free to rotate. The balls 11 are electrically dipolar in the presence of the fluid and so are subject to rotation upon application of an electric field, as by matrix-addressable electrodes 14a, 14b. The electrode 14a closet to viewing surface 15 is preferably transparent. An observer at I sees an image formed by the black and white pattern of the balls 11 as rotated to expose their black or white faces (hemispheres) to the viewing surface 15 of substrate 12.

Drawing Description Text (14):
FIGS. 12A-12B show a portion of an empty "eggcrate" substrate in side and 3-D cutaway views, respectively, and FIG. 12C shows how balls are placed in the eggcrate;

Drawing Description Text (15):
FIG. 13 schematically depicts a photomask used in fabricating an eggcrate substrate;

Drawing Description Text (16):
FIG. 14 shows a portion of, a partially completed eggcrate substrate structure during fabrication;

Drawing Description Text (17):
FIGS. 15A-B show side and top views, respectively, of an eggcrate substrate in the final stages of fabrication;

Drawing Description Text (20):
FIG. 17B shows a portion of a photomask used to fabricate an eggcrate substrate;

Detailed Description Text (7):
(3) an eggcrate substrate that helps to ensure accurate placement of the rotatable lens imaging elements within their array, and thereby helps to facilitate proper alignment (that is, registration) of the imaging element array with the lenses of the auxiliary optics array.

Detailed Description Text (8):
To motivate the discussion that follows, it is helpful to begin with an example of the inventive display in one embodiment, as shown in FIG. 2. Display 20 is similar in some respects to the known gyricon display 10 that was illustrated in FIG. 1 (PRIOR ART). Notably, display 20 has spherical balls 21 rotatably disposed in fluid-filled cavities 23 within a substrate 22, the balls 21 being rotatable within their respective cavities. Each of balls 21 is optically anisotropic. Also, each of balls 21 is electrically dipolar in the presence of the fluid and so is subject to rotation upon application of an electric field, as by matrix-addressable electrodes 24a, 24b.

Detailed Description Text (10):

Together, the lens array provided by balls 21 can be used to form an image. For example (and once again assuming aperture-mask type balls), balls such as those at 21a are rotated so as to present their transmissive aspects toward light-entry surface 25 of substrate 22 and thus toward light coming from a light source at L, here shown as a collimated beam of light. These balls 21a focus the incoming light from L so that the light emerges from light-exit surface 26. The auxiliary optics, here shown as an array 27 of converging lenses disposed between light source L and balls 21, helps the light to be focused correctly as is described below. Balls such as those at 21b are rotated so as to present their nontransmissive aspects toward light-entry surface 25 of substrate 22. Light from source L that encounters these balls via array 27 can be absorbed or reflected (depending on choice of aperture mask materials) at their surfaces, but in any event is blocked and not transmitted. An image of the focused, transmitted light pattern of balls 21 can be formed, as by projection of the transmitted light through a projection lens 28 onto a viewing screen 29. The projected image can, in turn, be seen by a favorably situated observer at I.

Detailed Description Text (12):
Substrate 22 of display 20 is an eggcrate substrate having a regular pattern of pre-formed cavities, here shown as cylindrical cavities. In both its structure and its manufacture, substrate 22 differs from substrate 12 of known display 10. Substrate 12 has spherical cavities 13 that are formed around balls 11: first, balls 11 are embedded in substrate 12, and then a dielectric fluid is applied to substrate 12, causing substrate 12 to swell, so that the cavities 13 form wherever the balls 11 happen to be. By contrast, in substrate 22 of display 20, cavities 23 are wholly or partially pre-formed, and then balls 21 are placed into the cavities, in a manner that is described below. In other words, the cavities 23 are formed first, and the balls 21 end up wherever the cavities are, instead of the other way around.

Detailed Description Text (13):
The regularity of the eggcrate structure of substrate 22 ensures that balls 21 are arranged in a highly regular fashion. This facilitates the fabrication of display 20, because it is much easier to place (that is, register) auxiliary optics lens array 27 with respect to the array of balls 21 so as to focus the light properly through each of balls 21, than would be the case if balls 21 were not so regularly arranged.

Detailed Description Text (14):
The remainder of the description is organized as follows: First, an explanation of the optics of spherical lenses is given. Then the rotatable lens, auxiliary optics, and eggcrate substrate components of the inventive display are described more fully. Thereafter, several embodiments of the invention are illustrated, showing in particular how the inventive technology can be used to make monochrome and color displays. Finally, some variations and extensions of the inventive technology are presented.

Detailed Description Text (16):
The rotatable lenses of the present invention can be built from transparent spheres, such as glass, plastic, or epoxy spheres. A transparent sphere has optically refractive properties that depend on the medium in which the sphere is disposed. In particular, if the sphere is made of a material having an index of refraction that is greater than the index of refraction of the surrounding medium, the sphere acts like a converging lens.

Detailed Description Text (25):
FIG. 4B shows a spherical lens ball 40 that is assumed to be immersed in a dielectric fluid (not shown) in an elastomer (also not shown). A converging lens, such as thin plano-convex lens 39, is situated between parallel incoming light (here represented by rays a and b) and ball 40. Lens 39 acts to focus the parallel beam of incoming light into a convergent beam. The beam is then further focused by ball 40, to a focal point 45 on the wall of ball 40 opposite the incoming light, as shown. To ensure that the light is properly focused, certain conditions must obtain for the radius of curvature R of lens 39 and also for the distance d that separates lens 39 and ball 40, d being measured from the nearest point on ball 40. Using equation [1] and setting L.sub.2 =2r (for example), it follows that lens 39 must have a focal length L.sub.1 =3.1 1r, so that its focal point lies well behind ball 40. This condition is met if

Detailed Description Text (31):
Also in FIGS. 5A-5B is a converging lens 49 that focuses incoming parallel light from a collimated light source (not shown), as represented by light rays a and b, in such a way that if ball 50 is oriented as shown in FIG. 5A, light rays passing through ball 50 focus at the back of ball 50 and thus at aperture 52. Lens 49 is needed because the refractive indices of ball 50 and the fluid that fills cavity 53 are such that, based on the refraction equations given above, the incoming light would otherwise be directed at a focal point behind ball 50 and so would not focus properly at aperture 52. Lens 49 can be part of an array of lenses that serves as the auxiliary optics for a gyricon display containing an array of spherical lens balls with aperture masks, including ball 50.

Detailed Description Text (35):
Also in FIG. 7 is a converging lens 69 that focuses incoming parallel light from a collimated light source (not shown), as represented by light rays a and b, in such a way that if ball 70 is oriented as shown in FIG. 7, light rays passing through ball 70 focus at the back of ball 70 and thus at dot 72. Lens 69 is needed because the refractive indices of ball 70 and the fluid that fills cavity 73 are such that, based on the refraction equations given above, the incoming light would otherwise be directed at a focal point behind ball 70 and so would not focus properly at dot 72. Lens 69 can be part of an array of lenses that serves as the auxiliary optics for a gyricon display containing an array of spherical lens balls with aperture masks, including ball 70.

Detailed Description Text (49):
The light beam, here represented by rays a and b, passes through window 96 and the air or vacuum surrounding balls 91 until it reaches the spherical surfaces of balls 91. There the light beam is refracted, as described earlier; in particular, equation [3] obtains, so that for each ball, the incoming light beam is focused at a single spot situated approximately at the back wall of the ball. For exemplary ball 91a, the light focuses approximately at spot 99. Optionally, and as shown, the focusing can be corrected by the use of a converging lens 89 that intercepts the incoming beam and changes it from a parallel beam to a suitably convergent one.

Detailed Description Text (65):
An array of converging lenses, one per spherical lens ball, is suitable for this purpose, as shown schematically in FIGS. 11A-11B. In each of these figures, a "fly's-eye" array 110 of plano-convex microlenses is positioned between an incoming light beam (represented by rays a and b) from a collimated light source (not shown) and an array of spherical lens balls 120. FIG. 11A shows a side view of array 110 and FIG. 11B an overhead view. As can be seen, each microlens of array 110 is preferably positioned coaxially with its corresponding spherical lens ball in array 120. For example, the central axes of exemplary microlenses 110a, 110b are aligned with the pupils in the aperture masks of balls 120a, 120b, respectively. Therefore, the lenses of array 110 serve to correct the focus of the incoming light beam so that the light rays converge properly at the aperture mask pupil or aperture stop (as the case may be) when the balls are appropriately oriented.

Detailed Description Text (68):
"Eggcrate" Substrate

Detailed Description Text (69):
To ensure proper registration of the fly's-eye lens array and the spherical lens balls, a highly regular array geometry is preferred, so that all lenses of the fly's eye array can simultaneously be registered with all of the spherical lens balls (that is, so that proper alignment of one microlens with one ball does not result in misalignment of another microlens with another ball). An ordinary elastomer substrate as practiced in known gyricon displays can be used if special care is taken to ensure that the balls are of highly uniform diameter and are placed in a close-packed array in the elastomer. However, another kind of substrate is preferable in displays of the present invention. This new kind of substrate, here called an Eggcrate substrate, has a regular array or pattern of hollow cells in it, and so resembles the interior of an egg carton or a honeycomb. The regular pattern of cells ensures regular placement and spacing of the spherical lens balls even if there are nonuniformities in ball diameter. In other words, the regularity of the geometrical structure of the eggcrate

substrate does not depend on uniformity of ball diameter or on careful placement of the balls in the substrate.

Detailed Description Text (70):
A portion of an empty eggcrate substrate 120 is illustrated in a side view in FIG. 12A, and in a three-dimensional cutaway view in FIG. 12B. Substrate 120 has transparent front and rear surfaces 125, 126 and contains a geometrically regular array of uniform cavities 123, which in this embodiment are cylindrical and are arranged in a monolayer in a closely packed hexagonal array geometry (as indicated by hexagon H). The cavity walls can be made opaque to reduce light leakage. Each cavity is filled with a transparent dielectric fluid (not shown), such as an oil, in this embodiment with an index of refraction closely matching that of the transparent material of substrate 120. In a working gyricon display, one ball is placed in each cavity of the eggcrate, as shown in FIG. 12C, where spherical lens balls 121 occupy cavities 123. Each ball 121 acquires an electrical dipole moment when immersed in the dielectric fluid that fills cavities 123.

Detailed Description Text (73):
Fabrication of "Eggcrate" Substrate

Detailed Description Text (74):
Unlike the substrates of known gyricon displays, the eggcrate substrate of the invention is not made from an elastomer sheet. Instead, it is precision-formed from the fly's-eye lens array in a manner that ensures it will closely match the geometry and spacing of the fly's-eye array, as will now be described.

Detailed Description Text (75):
A photo mask that is an array of spots is produced by shining a beam of collimated light through the fly's-eye lens array onto a photo plate situated near the focal plane of the fly's-eye lens array. This is illustrated schematically in FIG. 13. A light source (not shown) produces a collimated light beam, here represented by rays a and b, that is directed towards fly's-eye array 131. The light beam encounters, and is focused by, the microlens elements of array 131. In particular, light incident on exemplary microlens element 131a of fly's-eye lens array 131 is focused thereby to a point 132a that is located in the focal plane f of element 131a and directly behind element 131a with respect to the incoming light beam. A flat, previously unexposed photographic plate 132 disposed parallel to and slightly in front of or behind the focal plane f is illuminated by the focused light from element 131a and exposed thereby, so that when plate 132 is photographically developed, a spot appears on the plate. A similar spot appears for each microlens of the array. The spot diameters depend on the distance .DELTA. between focal plane f and the plane of plate 132. Plate 132, thus exposed and developed, becomes a mask for production of the eggcrate substrate.

Detailed Description Text (77):
When RISTON is exposed to ultraviolet light, it photohardens, so that when subsequently placed in a high-pH aqueous development solution, only the unexposed portions are dissolved. Thus RISTON can be etched to form the cylindrical cavities of the eggcrate substrate. Specifically, the photomask with the array of spots that was formed from the fly's-eye lens array is placed in contact with the RISTON surface of the coated glass plate. The assembly is then exposed to highly collimated ultraviolet light from a photoresist exposure system. This light is unable to penetrate the dots on the photomask, but all other parts of the RISTON surface are exposed and thus photohardened. Thereafter, the photomask is removed and the RISTON-coated glass plate placed in the aqueous development solution. The areas of the RISTON that were underneath the photomask spots during the UV exposure are dissolved away by the developer, leaving holes that are nearly cylindrical. (In practice, the holes are slightly tapered such that the diameter of the hole adjacent to the glass plate is less than that at the air interface.)

Detailed Description Text (83):
Other fabrication techniques can also be used to form the eggcrate substrate. For example, if it is desired to make the eggcrate substrate from epoxy rather than from RISTON, the foregoing etching process can be modified as follows: Instead of starting with a photomask having an array of spots, one uses the negative image, that is, an

array of holes in an opaque coating on the photomask. Going through the RISTON etch process outlined above yields an array of cylinders protruding from the glass plate. Next, a second glass plate is coated with a layer of uncured epoxy, and the two plates are pressed together and held together until the epoxy hardens. Subsequently the plates are pulled apart, so that the RISTON cylinders remain fixed in the epoxy coating. Thereafter, the RISTON cylinders are removed with a solvent that does not attack the epoxy (for example, acetone). The result is an epoxy eggcrate structure.

Detailed Description Text (87):
Registration Fly's-Eye Lens Arrays with Eggcrate Substrate

Detailed Description Text (94):
For a simple monochrome display, display 160 can be made with spherical lens balls having opaque aperture masks. In this case, application of an electric field in one of the directions perpendicular to the plane of the eggcrate substrate causes the balls in the vicinity of the applied field to rotate so that their aperture masks face towards the light source L, thus blocking the light and producing a black output. Application of an electric field in the opposite direction causes the balls to rotate 180 degrees so that their aperture masks face away from the light source L, so that light is transmitted through their pinhole apertures and a white output is produced.

Detailed Description Text (95):
In general, a gyricon display according to the invention can be made in various sizes and shapes, and using various materials for the gyricon balls, eggcrate substrate, and dielectric fluid. The inventive display also has other advantages inherent in gyricon displays. For example, they can be made thin and lightweight. They are optically bistable, in that an image, once displayed, is maintained even after the electric field is removed. Due to their bistability, the displays consume power only when a pixel changes state, so that the displays can operate at low power.

Detailed Description Text (99):
A subpixel pattern is shown schematically in FIG. 17A. A top view of an enlarged portion of eggcrate substrate 1010 is shown. Spherical lens balls of each color (RGB) are localized together in subpixels within eggcrate substrate 1010. Pixel 1070 includes red subpixel 1071, green subpixel 1072, and blue subpixel 1073. Each subpixel contains gyricon balls 1074, 1075, 1076 of its respective color only; for example, all the gyricon balls 1074 in red subpixel 1071 are red. The arrangement of the subpixels within each pixel can vary in different embodiments; for example, as shown in FIG. 17A, the subpixels can be arranged so as to form a hexagonal tiling pattern.

Detailed Description Text (101):
Fabrication Technique for Strategic Placement of Different Balls in "Eggcrate " Substrate

Detailed Description Text (102):
The RGB gyricon display is constructed from three different kinds of spherical lens balls, namely, balls with red aperture stops or masks, balls with green aperture stops or masks, and balls with blue aperture stops or masks. These three different kinds of balls are placed in different subpixel regions in the eggcrate substrate. A red subpixel contains balls with red coloration only, and does not contain balls of the other two kinds. Similarly, a green subpixel contains balls with green coloration only, and a blue subpixel contains balls with blue coloration only. To build this gyricon display, then, requires a manufacturing technique for placing the different kinds of balls in their respective different locations in the eggcrate substrate, so that the desired geometric pattern of red, green, and blue subpixels (e.g., the pattern of FIG. 17A) is obtained.

Detailed Description Text (103):
A technique for placement of gyricon balls at specified positions within an Eggcrate substrate will now be described. The technique can be used, in particular, to position red, green, and blue gyricon balls in any desired pattern of subpixels.

Detailed Description Text (104):
Turning to FIG. 17B, a photomask 171 of the type used to create an eggcrate substrate is illustrated. This photomask can be digitized at high resolution and, through

digital image processing, turned into three submasks. For example, spots 172 other than in vicinity 172a can be eliminated in the digital domain, producing the modified mask image 173 shown in FIG. 17C. This mask image can be used to generate a modified photomask. Similar processing can be done for spots in vicinities 172b and 172c, so that three modified photomasks are produced in all, one for each subpixel color.

Detailed Description Text (105):
A metal (e.g., nickel) screen is then formed from each of the modified photomasks. That is, there is one screen for each of the red, green, and blue subpixel patterns. An example of such a screen is shown in FIG. 17D. Screen 177 is thin and is solid except for holes 178 that correspond to the places in the eggcrate substrate where the balls for a subpixel color (e.g., red) are to be placed.

Detailed Description Text (106):
During fabrication of the eggcrate substrate, just prior to the placement of balls in the cavities, each of the metal screens in turn is aligned with and overlaid atop the open cylindrical cavities of the eggcrate. Then balls having the appropriate color (e.g., red) are deposited on the screen. The balls fall through the holes 178 into the cylindrical cavities of the eggcrate. To expedite this process, the screen can be gently vibrated. Each cavity of the eggcrate is sized to accommodate only one ball, so once a cavity is filled, no additional balls can enter it. Once all the cavities for that color subpixel pattern are filled, the process is repeated with the remaining screens for the other two colors.

Detailed Description Text (110):
In display 180, alignment of component units 181, 182, 183 within the stack is crucial, because light emerging from one imaging element (such as exemplary element 181a) in unit 181 must thereafter pass through corresponding imaging elements in the remaining units 182, 183 (such as exemplary elements 182a, 183a, respectively). To achieve correct alignment, the fly's-eye arrays and eggcrate substrates used in the component units should have identical geometry and spacing. For example, arrays 184, 185, 186 can all be precision-formed from molds derived from the same pattern. Thereafter, registration of the component units with respect to each other can be achieved, for example, by optical alignment techniques. For example, with all spherical lens balls of units 181 and 182 in their fully transmissive orientation, the amount of light passing through the partial stack formed by these units, is maximized by holding unit 181 fixed and adjusting the position of unit 182. Thereafter, the process can be repeated for unit 183 and any additional units.

Detailed Description Text (123):
The optical anisotropy of a spherical lens gyricon ball need not be based on color. Other optical properties can vary as different aspects of the gyricon ball are presented to an observer, including (but not limited to) polarization, birefringence, phase retardation, light scattering, and light reflection. In general, the gyricon balls can be used to modulate light in a wide variety of ways.

Detailed Description Text (124):
The incident light that encounters a gyricon display need not be restricted to visible light. Given suitable materials for the gyricon balls, the incident "light" can be, for example, infrared light or ultraviolet light, and such light can be modulated by the gyricon.

Detailed Description Text (126):
Color gyricon displays according to the invention can be built in many ways other than those previously described, For example, an RGB transmissive display can be built of three separate spherical lens arrays, one for each color, whose images are combined by optical arrangements similar to those used in projection television screens. As another example, for an RGB display based on aperture masks, the color can be provided by a transparent color coating or by colorants added to the fly's-eye array, rather than by using colored materials for the spherical lens ball itself.

Detailed Description Text (127):
Certain of the above-mentioned three components of the inventive technology--that is, rotatable lenses, auxiliary optics, and eggcrate substrates--can be useful in other contexts and combinations than those previously described. For example, a gyricon

display having an eggcrate substrate can be made with imaging elements other than rotatable lenses. Auxiliary optics (either fly's-eye arrays or other optical elements, or any combination) can be used in a gyricon display based on imaging elements other than rotatable lenses. Rotatable-lens balls of kinds other than the ones shown here can be made, and other optical configurations for incorporating the balls into various kinds of gyricon displays can be developed.

Other Reference Publication (5):
H.-J. J. Yeh and J. S. Smith, "Fluidic Self-Assembly for the Integration of GaAs Light-Emitting Diodes on Si Substrates," IEEE Photonics Technology Letters, vol. 6, No. 6, Jun. 1994, pp. 706-708.

CLAIMS:

12. A device comprising:

a substrate comprising a matrix having a plurality of cavities;

an optically transmissive dielectric fluid having a first refractive index, disposed in the cavities of the matrix; and

a plurality of optically anisotropic particles disposed in the cavities of the matrix in contact with the fluid, each particle having at least one optically transmissive region having a second refractive index,

each particle providing a first optical modulation characteristic when disposed in the fluid in a first orientation with respect to a flux of optical energy,

each particle further providing a second optical modulation characteristic when disposed in the fluid in a second orientation with respect to a flux of optical energy,

each particle having an anisotropy for providing an electrical dipole moment, the electrical dipole moment rendering the particle electrically responsive such that when the particle is rotatably disposed in an electric field while the electrical dipole moment of the particle is provided, the particle tends to rotate to an orientation in which the electrical dipole moment aligns with the field,

a rotatable disposition of each particle being achievable while said particle is thus disposed in the substrate, said particle, when in said rotatable disposition, not being attached to the substrate.

13. Apparatus comprising:

the device recited in claim 11; and

means for producing an electric field to facilitate a rotation of at least one particle rotatably disposed in the substrate.

17. Apparatus comprising:

a substrate having an optically transmissive window; and

a plurality of particles disposed in the substrate,

each particle having an anisotropy for providing an electrical dipole moment, the electrical dipole moment rendering the particle electrically responsive such that when the particle is rotatably disposed in an electric field while the electrical dipole moment of the particle is provided, the particle tends to rotate to an orientation in which the electrical dipole moment aligns with the field,

a rotatable disposition of each particle being achievable while said particle is thus disposed in the substrate, said particle, when in said rotatable disposition, not being attached to the substrate,

each particle, when rotatably disposed in the substrate, being disposable in first and second rotational orientations with respect to the optically transmissive window,

each particle, when disposed in at least one of said first and second rotational orientations, producing a refractive effect when illuminated by a flux of optical energy through the substrate window.

18. The apparatus of claim 16 wherein:

each particle includes an optically transmissive region having a first index of refraction;

the substrate contains an optically transmissive dielectric fluid having a second index of refraction, the particles being disposed in contact with the fluid; and

the refractive effect is produced as a result of said first and second indices of refraction differing from one another.